APPLICATION UNDER UNITED STATES PATENT LAWS

Invention:　　INTEGRATED OPTICS SAMPLING DEVICE AND ITS FABRICATION METHOD

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☐ Provisional Application

☐ Regular Utility Application

☐ Continuing Application
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　　by reference

☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

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SPECIFICATION

INTEGRATED OPTICS SAMPLING DEVICE AND ITS FABRICATION METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001]   This application is the U.S. National Phase of International Application No. PCT/FR03/50174, filed December 15, 2003, which, in turn, claims priority from French Application No. 02-15918, filed December 16, 2002, the entire contents of both applications being hereby incorporated by reference.

~~TECHNICAL FIELD~~
Field of Invention

[0002]   This invention relates to an integrated optics sampling device as well as the fabrication method of this element.

~~The invention has applications in all fields requiring the sampling of a light wave for example to measure and/or check the characteristics of the wave. The invention is especially well suited to the field of optical amplifiers for sampling a light wave input and/or output of an optical amplifier or even in the field of spectral filters.~~

~~STATE OF THE PRIOR ART~~
Description of Related Art

[0003]   Currently, to sample a light wave, a coupler or a divider is generally used.

[0004]   ~~The~~**Parameters of the** coupler~~'s parameters~~ are set to sample from a light wave ~~transported for~~**transmitted in** a wave guide, ~~whilst~~**while the parameters of** the divider~~'s parameters~~ are set to divide the initial light wave into determined parts.

[0005]   Figure 1 shows ~~diagrammatically by means of a~~ block diagram, ~~a~~**of a conventional** linear filter associated

~~to~~**with** a **conventional** sampling device ~~of the prior art~~ for spectral checking of ~~the~~ filtering.

[0006]   A source 2 is represented in this figure~~,~~**.** **The source 2** emitting **emits** a light wave E of intensity I_0 in a thin spectral band assimilated to a single ~~wave length.~~ **wavelength.** A sampling device 4 (a coupler for example) receives this signal of intensity I_0, sampled at I_1, with a sampling rate γ and transmits ~~to the linear filter 8,~~ a signal with an intensity I_0' ~~.~~ **to the linear filter 8.** The output signal of the filter has an intensity I_2 such that ~~the~~**a** ratio between the signal I_2 ~~issued~~**output** from the filter and the sampled signal I_1 is expressed as follows:

$$I_2/I_1 = \frac{1-\gamma}{\gamma} \times (a \times d\lambda + t_m)$$

[0007]   where $d\lambda = \lambda-\lambda_m$ for a filter 8 of slope a around a central wave length λ_m and with a value t_m at this ~~wave length.~~ **wavelength.**

[0008]   The signal I_2 measured at the filter output is therefore proportional to the emission wave length. If the ~~latter~~**wavelength** changes, it is possible for example to correct this variation by servo controlling the spectral position of the source on the preceding measurement.

[0009]   Even though this ~~is~~**may be** satisfactory in certain respects, these devices comprise separate sampling and filtering elements which ~~induces~~**induce** losses and ~~makes~~**make** the complete system more complex.

[0010]   Furthermore, in the field of filters, an incident light wave is generally separated into two components**,** **one** of which ~~one~~ is transmitted and the other is not, at distinct spectral intervals, at the component output. ~~However, for~~ **For** certain applications, it may ~~also~~ be useful to measure and/or check the part of the wave not transmitted.

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[0011]   In the field of optical fibres, to recover the part of the wave not transmitted, ~~it is know to have~~ a detection element~~,~~ **is used** at the edge of the optical cladding. On this subject ~~we,~~ **one** can refer to the patent WO/0216979.

[0012]   Figure 2 shows diagrammatically an example of this type in the case of a an optical fibre filter formed for a long period grating.

[0013]   Figure 2 is a partial cross section of an optical fibre 1, comprising a core 3, an optical cladding 5 surrounding the core and a grating 7 made in a part of the core 3.

[0014]   This cross section is in a plane which contains the direction z of propagation of the light wave in the core.

[0015]   The grating 7 ~~permits~~**is configured to provide** a zone of interaction ~~to be created~~ between the core and the cladding and to couple in the cladding, a part C (~~called~~ the coupled wave) of an initial light wave E. The coupled wave C in the cladding is shown diagrammatically by arrows. At ~~the~~**an** output of the zone of interaction, the core ~~thus~~ transports ~~the~~**a** part S of the non coupled wave in the cladding.

[0016]   After the zone of interaction, a detection element D such as a photo-detector, is positioned at ~~the~~**an** edge of the optical cladding.

[0017]   In the optical fibres, **because of** the construction dependency between the core and the cladding ~~means that~~ the detection element can only be positioned at the edge of the cladding, if the propagation of the wave in the core is not to be disrupted. The axis of the detector is ~~then~~ perpendicular to the direction of propagation of the signal in the cladding. Consequently, only a part of the guided signal in the cladding is detected.

[0018]   ~~Furthermore, to~~**To** improve the detection, it can be envisaged, as shown in ~~figure~~**Figure** 2, to create a cavity 6 in

the fibre cladding to insert the detector. ~~In spite of this layout~~ **However**, the detection element ~~cannot~~**may still not be able to** detect the entire guided signal in the cladding**. In addition**, ~~and furthermore~~ the cavity ~~that has to be~~ machined in the cladding ~~makes~~**may render** the component more fragile.

~~DESCRIPTION~~**BRIEF SUMMARY** OF THE INVENTION

[0019]   ~~The purpose~~**An aspect of an embodiment** of this invention is to ~~propose~~**provide** an integrated optics sampling device which permits **overcomes** the problems of the prior art ~~to be overcome~~.

[0020]   ~~In particular~~**For example**, the sampling device **according to an embodiment** of the invention allows part of ~~the~~**a** light wave to be sampled for filtering~~, which avoids~~**.** **This allows to avoid** the problems related to couplers and dividers and permits, when using a cladding that is independent of a guide core, to recover the complete signal sampled at ~~the~~**an** output of the device.

[0021]   ~~More precisely~~**Specifically**, the sampling device **according to an embodiment** of the invention comprises ~~in~~ a substrate, a wave guide core capable of transporting a light wave **in the substrate** and an optical cladding~~, with at~~**.** **At** least one portion of the cladding ~~surrounding~~**surrounds** at least one portion of the core in a zone ~~called the zone of interaction, the said zone comprising along others a grating capable of coupling~~**of interaction.** **The zone of interaction comprises a grating configured to couple** part of the light wave in the cladding~~, the~~**.** **The** coupled part of the wave ~~being called~~**, i.e.,** the coupled wave, ~~where~~ the refractive index of the cladding is different from the refractive index of the substrate ~~and~~**.** **The refractive index of the cladding is** lower than the refractive index of the core, at least in ~~the~~**a** part of the cladding ~~next~~**adjacent** to the core in the zone of interaction.

[0022]   By surrounding, it is meant that the fundamental profile mode of the guide core has a maximum ~~amount~~**intensity** that is included in the index profile of the cladding. In this way, the profile of the fundamental mode of the core may be totally or partially included in the index profile of the cladding~~, which results~~. **This translates (**at structural level**)** in **having** a core ~~that may be~~ located anywhere ~~at all~~ in the cladding**,** including at its edge~~, in which~~. **In that** case**,** the core may be partially outside of the cladding.

[0023]   The cladding of the sampling device of the invention is generally associated ~~to~~**with** at least one recovery and treatment element so as to recover and treat all or part of the coupled wave. This element will be called the first recovery and treatment element.

[0024]   ~~Thus~~**The** first recovery and treatment element associated ~~to~~**with** the device **according to an embodiment** of the invention permits the recovery and then treatment of all or part of the coupled wave~~, which~~. **The coupled wave** is the complementary part of the non coupled wave, with respect to the initial wave. ~~Knowledge of~~ **Knowing** the initial wave **characteristics** and the coupled wave ~~permit the non-coupled wave to be characterised if necessary, which in general is the~~**characteristics allows one to determine the characteristics of the non-coupled wave. The non-coupled wave is, in general is a** useful part of the light wave.

[0025]   ~~Of course, this~~**However, it must be appreciated that the** sampling device may be associated to a second recovery and treatment element in order to recover and treat directly all or part of the non coupled wave of the core~~,~~**.**

[0026]   According to**an embodiment of** the invention, the core of the guide has a refractive index n_c and the optical cladding has a refractive index n_g such that $n_c > n_g$. Furthermore, a grating is created in the zone of interaction to couple at least one guided mode in the core, to one or more

cladding modes. The cladding modes spread in the same direction as the core modes.

[0027]   The coupling between the different modes takes place for a spectral band of central wave length λ_j. By spectral band it is meant a band with a set of wavelengths with a central ~~wave length~~**wavelength** and a determined ~~band width, a~~**bandwidth. A** light wave can comprise one or more spectral bands.

[0028]   ~~In~~**For example, in** the ~~specific~~ case of long period gratings, the coupling for an elementary grating between the different modes takes place for determined wave lengths λ_j given for the following known relationship:

$$\lambda_j = \Lambda \times (n_0 - n_j) \qquad\qquad (1)$$

[0029] where:

[0030] n_0 is the effective index of a guided mode in the core,

[0031] n_j is the effective index of the cladding mode number j,

[0032] λ_j is the resonance wave length for the coupling in mode j,

[0033] Λ is the period of the grating.

[0034] Generally speaking, the coupling results in an energy transfer between the guided mode(s) in the core and the cladding mode(s) for the ~~wave lengths~~**wavelengths** λ_j. The energy coupled in the cladding modes then spreads in the cladding (the cladding may be assimilated to a large specific guide) and the non coupled energy continues to spread in the core ~~and~~**. The non-coupled energy** has a power spectrum with energy losses for the ~~wave lengths~~**wavelengths** λ_j on spectral bands called filtering bands.

[0035] When there is only a**relatively** small difference between the effective indices n_0 and n_j (a few 10^{-2} to a few

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10^{-3}) and the range of ~~wave lengths concerned for~~**wavelengths of concern in** the optical guiding is around 1.5 μm, the relationship (1) shows ~~us~~ that the grating periods are around a few dozen μm to a few thousands of μm.

[0036]   The zone of interaction thus permits to filter spectrally part of the initial wave. The filtered part which is called the coupled or sampled part of the initial wave is then transported ~~for~~**by** the cladding ~~whilst the non-filtered part which is to say~~**while** the non-filtered part remains in the guide core.

[0037]   The ~~creation~~**fabrication** of the integrated optics sampling device ~~permits the formation~~**allows to form** in the substrate ~~of the~~**a** wave guide core independently of the cladding and vice versa.

[0038]   By independence of the core and the cladding, it is meant that ~~they~~**the core and the cladding** can exist in a substrate independently from one another. In other words, the core can exist without the cladding and the cladding can exist without the core, contrary to ~~the~~ fibres.

[0039]   The independence of the core and the cladding ~~thus makes possible~~**allows** more possibilities than ~~with~~**in** optical fibres. ~~Thus~~ **Hence**, outside ~~of~~ the zone of interaction, the cladding may no longer surround the core, which ~~makes it possible~~**allows** to have two distinct optical channels respectively formed for the core and the cladding. ~~Thus the~~ **The** cladding only influences the propagation of a light wave in the associated guide core in the part which surrounds the core and the cladding can guide or transport light waves independently of the core.

[0040]   The spatial separation of the core and the cladding permits the coupled signal to be recovered directly or ~~not~~**indirectly** without any risk of interference with the non coupled signal ~~transported~~**propagating** in the core.

[0041]   The first recovery and treatment element may thus be optically **connected to one end of the cladding** more easily ~~to one end of the cladding~~**,** without ~~causing impedance for~~**being impeded by** the core in order to recover all or part of the coupled wave in the cladding depending on the applications ~~targeted~~**sought**.

[0042]   According to ~~a first~~**one** embodiment **of the invention**, the first recovery and treatment element comprises an optical element which may ~~advantageously~~ be a measuring element, positioned directly at one end of the cladding to measure the filtered wave.

[0043]   According to a second embodiment **of the invention**, the first recovery and treatment element comprises a second zone of interaction and an optical element which may **be,** for example ~~be~~**,** a measuring element~~; the~~**. The** second zone of interaction is formed in the substrate, ~~for~~**by** a second guide core situated in a portion of the cladding and ~~for~~**by** a grating capable of coupling, in the second **guide** core, the coupled wave which spreads in the cladding~~, the said~~**. The guide** core ~~being~~**is** optically connected **to the optical element** outside of ~~this~~**the** second zone of interaction ~~to the optical element~~.

[0044]   The cladding does not necessarily have a uniform structure. In particular, the section of the cladding in the first zone of interaction may be larger than ~~that~~**the section of the cladding** of the second zone of interaction. Consequently, the section of the cladding between these two zones of interaction can be variable. Furthermore, the first and the second cores may be decentred with respect to ~~one~~ ~~another~~**each other** in the cladding.

[0045]   The characteristics of the second zone of interaction are however most often the same as those of the first zone of interaction as ~~its~~**a** function **of the second zone,** is to re-couple the coupled wave in the cladding, in the second core.

[0046]   ~~Regardless of~~**In either** the first **embodiment** or the second ~~embodiments~~**embodiment of the invention**, it is possible to place at one end of the guide core the second recovery and treatment element, in order to recover and treat all or part of the non-coupled wave in the cladding. In this ~~embodiment~~**instance**, the sampling device ~~is thus~~**can be** associated ~~to~~**with** two recovery and treatment elements which can ~~permit~~**allow** a double detection to be ~~made:~~**implemented: a** detection ~~on~~**of** the coupled signal in the cladding and **a** detection ~~on~~**of** the non-coupled signal.

[0047]   ~~Advantageously, the~~**The** first and/or second recovery and treatment element comprise(s) at least one optical element which ~~is~~**can be,** for example**,** a measuring element such as a photo-detector or a group of photo detectors, capable of characterising at least spectrally the wave measured~~, or~~**. Alternatively, the optical element can be** a suitable optical element for the application in question~~;~~ ~~this~~**. The** optical element ~~may possibly~~**can** be associated ~~to~~**with** a formatting element such as a lens, a lens fibre. The formatting element ~~permits~~**allows** to target the wave to be measured on the photo-detector.

[0048]   According to a third embodiment**_of the invention_,** in which the core and the cladding are not ~~separate~~**separated** after the zone of interaction, the first and the second recovery and treatment elements form a single recovery and treatment element~~which~~**. The single recovery and treatment element** comprises a matrix of optical elements such as photo-detectors with ~~possibly~~**optionally** an optical adaptation~~, with~~ ~~part~~**_device. Part_** of the matrix ~~permitting~~**is configured to permit** the coupled wave to be recovered and possibly measured ~~the~~**. The** other part of the matrix permitting **is configured to permit** the wave non coupled to be recovered and possibly measured.

[0049]   ~~In fact, thanks to the~~**The** independence of the core and cladding, the size of the cladding can be adapted to a given matrix of detectors~~, this~~. **This** is not possible ~~with~~**in** the optical fibres which in particular have the disadvantage of a circular cladding ~~which is consequently~~**and thus are** poorly adapted to the form of the matrix in lines and columns.

[0050]   The characteristics of the one or more zones of interaction are determined following the one or more spectral bands of the wave that are to be sampled for coupling.

[0051]   The efficiency of the coupling between the modes depends on the length of the grating and the coupling coefficient K_{0J} between ~~the~~ 0 and j modes. This coefficient is provided ~~for~~**by** the spatial recovery integral of the 0 and j modes, weighted ~~for~~**by** the index profile induced for the grating. ~~We therefore have a~~ **The following** relationship of the type:

$$K_{0J} \propto \iint \xi_0 . \xi_J^* . \Delta \Delta n s \ (2)$$

[0052]   **is obtained** where:

[0053] ξ_0 and ξ_j **are** the transversal profiles of the 0 et j modes, and ξ_j^* **is** the conjugate complex of ξ_j,

[0054] Δn **is** the amplitude of the effective index modulation induced for the grating in a plane perpendicular to the direction of propagation of the wave,

[0055] ds is an integration element in a plane perpendicular to the axis of propagation of the wave.

[0056]   The modification of K_{0j} is obtained by varying the profile of the modes and/or ~~t~~**the** induced ~~he~~ index profile of the grating~~, in~~. **In** other words**, the modification of K_{0j} is obtained** by varying the opto-geometrical characteristics of the cladding and/or of the core (dimensions, index level, etc.) and/or the characteristics of the grating (Δn, position

of the grating with respect to the core and the cladding, etc.).

[0057] In general, to modify the characteristics of the zones of interaction, the following parameters may be varied:

[0058] the length L of the grating,

[0059] its period Λ,

[0060] ~~An~~ the amplitude of the effective index modulation induced for the grating $\underline{\Delta \mathbf{n}}$,

~~n_{eo}~~

[0061] the index of the core~~,~~ $\underline{\mathbf{n}_{co}}$,

[0062] ~~ϕ~~ the phase of the grating $\underline{\phi}$.

[0063] According to **an embodiment of** the invention, the cladding is created artificially in the substrate, at least in the one or more zones of interaction and independently of the core and the substrate.

[0064] Generally speaking, we will call artificial cladding this type of cladding and artificial cladding grating **(ACG)**, a zone of interaction.

[0065] The substrate can ~~of course~~ be created ~~for~~**from** a single material or ~~for~~**from** the superposition of several layers of ~~material.~~**materials.** In this case, the refractive index of the cladding is different ~~to~~**from** the refractive index of the substrate, at least in the layers next to the cladding.

[0066] ~~Advantageously, each~~**Each** cladding has a refractive index higher than that of the substrate.

[0067] According to **an embodiment of** the invention, the integrated optics guide may be a ~~planarian~~**planar** guide, when the light is confined in a plane containing the direction of propagation of the light or a micro guide, **or** when the light is confined in two directions that are transversal to the direction of propagation of the light.

[0068] Furthermore, the grating of a zone of interaction ~~is~~**can be** formed in the core of the guide and/or in the cladding and/or in the substrate. A grating may comprise a

succession of elementary gratings. It may be periodic or pseudo-periodic.

[0069] Thus, for example for a cladding, the bigger its dimensions and index level **are**, ~~then~~ the higher the number of cladding modes **are** allowed to spread ~~and the~~. **As a result,** more spectral filtering bands will be possible. This can be ~~an advantage if looking for~~**useful if** multiple filtering **is intended** or to have more choice in the selection of a filtering mode.

[0070] ~~If~~**On the other hand, if** the aim is to limit the number of cladding modes that can be coupled, it is on the contrary better to reduce the opto-geometrical dimensions of the cladding.

[0071] ~~As concerns~~**With respect to** the core, its dimensions and index level determine the characteristics of the mode that spreads ~~there.~~**therein.** Furthermore, the higher the differences of index between the core, the cladding and the substrate, the more chance there is **to** potentially ~~of~~ ~~having~~**have** couplings for low grating periods as shown by the equation (1) (at a ~~wave length~~**wavelength** of given resonance, the period is inversely related to the difference of index between the guided mode of the core and the cladding mode).

[0072] By modifying the position of the core, the grating and the cladding, different couplings may be generated. ~~In fact~~ **Indeed,** ~~we~~**it** can ~~see~~**be seen** clearly from ~~the~~ equation (2) that the coupling force depends on the relative position in the transversal plane **(relative** to the axis of propagation**)** of the profiles of the cladding mode, of the guided mode in the core and of the grating.

[0073] The sampling device **according to an embodiment** of the invention may be used with many optical components. It is particularly useful in the case of filtering components such as linear filters or gain flatteners used for example with optical amplifiers.

[0074]   In ~~this case and according to one particularly advantageous~~ **addition, the invention has applications in all fields where the sampling of a light wave is used, for example, to measure and/or check the characteristics of the wave. The present invention is , for example, especially well suited for application in the field of optical amplifiers for sampling a light wave input and/or output of an optical amplifier or even in the field of spectral filters.**

[0075]   **According to one** embodiment **of the invention**, the zone of interaction of the sampling device is created so that ~~It~~**it** both filters and samples. The parameters of the zone of interaction are therefore adapted to the desired filtering function, which may or may not be of the evolved type, the grating of the zone of interaction comprises at least two elementary gratings.

[0076]   Thus, ~~the~~ parameters for each elementary zone of interaction associated to an elementary grating may be ~~at least~~ selected from **at least** the following:

[0077] the length L of the grating or elementary gratings,

[0078] the period Λ of the grating or elementary gratings,

[0079] the profile of the grating or elementary gratings,

[0080] the position of the grating or elementary gratings in the corresponding zone of interaction,

[0081] ~~An~~ the amplitude of the effective index modulation induced for the grating or the elementary gratings $\mathbf{\Delta n}$,

[0082] ϕ the phase of the grating or elementary gratings $\mathbf{\phi}$,

[0083] the dimensions of the cladding which may be variable,

[0084] the dimensions of the core which may also be variable,

[0085] the value of the refractive index of the cladding which may also be variable,

[0086] ~~n_{eo}~~ the value of the index of the core in the substrate $\mathbf{n_{co}}$,

[0087] the position or the positions of the core in the cladding.

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[0088]   According to one ~~preferred~~ embodiment **of the invention**, the cladding and/or the core of the guide and/or the grating may be created ~~for~~**by** all types of ~~technique~~**techniques** permitting the refractive index of the substrate to be modified. ~~We can mention in particular the ion exchange techniques.~~ **For example**, the ionic implantation and/or radiation, for example ~~for~~**, by** laser exposure or laser photo inscription or even the depositing of layers **can be used**.

[0089]   The ion exchange technology in glass is of ~~particular~~ interest but other substrates **other** than glass may ~~of course~~ be used, such as, for example, the crystalline substrates of the KTP or $LiNbO_3$ types, or even $LiTaO_3$.

[0090]   More generally, the gratings may be created ~~for~~**by** all techniques permitting the effective index of the substrate to be changed. To the techniques ~~we have already~~ mentioned **above**, we can ~~therefore~~ add in particular the grating creation techniques for etching the substrate. ~~This~~ **The** etching can be carried out above the cladding or in the portion of cladding of the zones of interaction and/or ~~possibly~~ in the core portion of the zones of interaction .

[0091]   The pattern of the grating may be obtained either ~~for~~**by** laser sweeping if radiation is used, or ~~for~~**via** a mask. ~~The latter~~ **A mask that** may be **used is** the mask which ~~permits~~**is used in the fabrication of** the core and/or the cladding ~~or~~**. Alternatively,** a specific mask ~~to~~**may** be ~~obtained~~**used** to create the grating.

[0092]   The invention also relates to a fabrication method of a sampling device as previously defined~~, the~~**. The** cladding, the guide core and the grating ~~being~~**are** respectively created to modify the refractive index of the substrate so that at least in ~~the~~**a** part of the cladding next to the core and at least in each zone of interaction, the refractive index

of the cladding is different from the refractive index of the
substrate and lower than the refractive index of the core.

[0093]   According to ~~a preferred~~an embodiment~~, the method~~
of the invention**, the method** comprises the following steps:

[0094] a) introduction of a first ionic species in the
substrate ~~so as to permit the optical cladding to be obtained
after step c)~~,

[0095] b) introduction of a second ionic species in the
substrate ~~so as to permit the guide core to be obtained after
step c)~~,

[0096] c) burying of the ions introduced in steps a) and b) ~~so
as to obtain the cladding and core of the guide~~,

[0097] d) creation of the grating.

[0098]   The order of the steps may of course be inverted.

[0099]   The introduction of the first and/or second ionic
species ~~is advantageously~~**can be** made for an ionic exchange, or
for ionic implantation.

[00100]   The first and second ionic species may be the same
or different.

[00101]   The introduction of the first ionic species and/or
the second ionic species may be made with the application of
an electrical field.

[00102]   In the case of an ionic exchange, the substrate
~~must contain~~**contains** ionic species capable of being exchanged.

[00103]   According to one ~~preferred~~ embodiment**of the
invention**, the substrate is made of glass and contains Na^{+^+}
ions introduced beforehand, and the first and second ionic
species are Ag^+ and/or K^+ ions.

[00104]   According to ~~a first~~**an** embodiment**of the
invention**, the step a) comprises the creation of a first mask
comprising a pattern capable of obtaining the cladding~~, the~~_._
The first ionic species ~~being~~**are** introduced through this first
mask ~~and step~~_._ **Step** b) comprises the elimination of the first
mask and the creation of a second mask comprising a pattern

capable of obtaining the core~~, the~~**. The** second ionic species ~~being~~**are** introduced through this second mask.

[00105] According to ~~a second~~**an** embodiment **of the invention**, the step a) comprises the creation of a mask comprising a pattern capable of obtaining the cladding and the core~~, the~~**. The** first and the second ionic species of steps a) and b) ~~being~~**are** introduced through this mask. This embodiment is in general ~~limited~~**applicable** to the case ~~of~~**in which** the core and the cladding **are** not ~~being~~ separated in the substrate.

[00106] The masks used in the invention are for example made of aluminium, chrome, alumina or **a** dielectric material.

[00107] According to ~~a first~~**an** embodiment of **the invention in** the step c), the first ionic species is buried at least partially before step b) and the second ionic species is buried at least partially after step b).

[00108] According to ~~a second~~**an** embodiment of **the invention, in** the step c), the first ionic species and the second ionic species are buried simultaneously after step b).

[00109] According to ~~a third~~**an** embodiment of **the invention, in** the step c), the burying comprises a deposit of at least one layer of refractive index material ~~advantageously~~**, for example,** lower than that of the cladding, on the surface of the substrate.

[00110] This mode may of course be combined with the two previous modes.

[00111] ~~Advantageously~~**In an embodiment of the invention**, at least a part of the burying is carried out with the application of an electrical field.

[00112] Generally before the burying under a field and/or the depositing of a layer, the process **according to an embodiment** of the invention may comprise among others**,** burying for re-diffusion in an ionic bath.

[00113]   This re-diffusion step may be carried out partially before step b) to re-diffuse the ions of the first ionic species and partially after step b) to re-diffuse the ions of the first and second ionic species. This re-diffusion step may also be carried out completely after step b) to re-diffuse the ions of the first and second ionic species.

[00114]   By way of example this re-diffusion is obtained by plunging the substrate in a bath containing the same ionic species as that formerly contained in the substrate.

[00115]   ~~Step~~**In step** d) ~~of~~**,** the creation of the grating may be carried out independently of steps a) and b) or be carried out simultaneously during step a) and/or step b) by using the same masks**,** for example.

[00116]   Other ~~characteristics and advantages~~**aspects** of the invention will become clearer in the following description, ~~in~~**with** reference to the figures of the appended drawings. This description is given purely by way of illustration, and is non-restrictive.

BRIEF DESCRIPTION OF THE ~~FIGURES~~**DRAWINGS**

[00117]   **In the accompanying drawings,** Figure ~~1, already described, diagrammatically~~**1** shows a block diagram of a **conventional** filtering device with a **conventional** sampling device of the prior art~~,~~**.**

[00118]   Figure ~~2, already described, diagrammatically~~**2** shows a cross section of an optical fibre with a known sampling element~~,~~**.**

[00119]   ~~figure 3 diagrammatically~~**Figure 3** shows a cross section of a first embodiment of a sampling device **according to an embodiment** of the **present** invention~~,~~**.**

[00120]   ~~figure~~**Figure** 4 ~~diagrammatically~~ shows a cross section of a ~~second embodiment d'un~~ sampling device **according to an embodiment** of the invention~~,~~**.**

[00121]   figureFigure 5 diagrammatically shows a section of a variant of the embodiment of figure 3,shown in Figure 3;

[00122]   figureFigure 6 diagrammatically shows a section of a variant of the embodiment of figureshown in Figure 4 in which the cladding has a variation of section,;

[00123]   figuresFigures 7a and 7b diagrammatically show a cross section of a third embodiment of a sampling device according to an embodiment of the invention,;

[00124]   figureFigure 8 diagrammatically shows a cross section of an example of an application of a sampling device of the invention with an amplification device,;

[00125]   figureFigure 9 diagrammatically shows a section of another application example of a sampling device of the invention with a filtering device, according to an embodiment of the invention;

[00126]   figuresFigures 10a to 10d diagrammatically show a cross section of an example of the creation process of a sampling element according to an embodiment of the invention,;

[00127]   figuresFigures 11a to 11d diagrammatically show variants of the creation of the mask pattern permitting a grating to be made, according to an embodiment of the invention; and

[00128]   figureFigure 12 shows in cross section a variant of the embodiment of the device of the invention, with a grating in the cladding according to an embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[00129]   To simplify the description, by way of example, we will consider that the zone of interaction only comprises an elementary grating included in the guide core of the device.

[00130]   Figure 3 diagrammatically shows, in a cross section, a first example of a sampling device according to an embodiment of the invention made in integrated optics.

[00131]   This cross section is in a plane parallel to the surface of the substrate containing the direction z of propagation of the light wave.

[00132]   This sampling device comprises in a substrate 15, a wave guide core 17, a cladding 19 and a grating 21 created by way of example in part of the core. The zone of interaction I corresponds to a zone of the substrate in which the core, the cladding and the grating are present.

[00133]   As ~~we have already seen~~**described above**, the independence of the core and the cladding ~~permits~~**allows** more flexibility and, in particular, to dissociate the core and the cladding. Thus, outside of the zone of interaction, the cladding can no longer surround the core. The cladding only influences the propagation of a light wave in the associated guide core in the part surrounding the core and the cladding can guide or transport light waves independently of the core. In this way, the wave transported ~~for~~**by** the cladding may be recovered more easily at one end of the cladding without being hampered by the core

[00134]   ~~In~~**As shown in** this figure, the recovery and treatment element 33 can ~~thus~~ be optically connected more easily to one end of the cladding without being hampered by the core and recover all or part of the coupled wave in the cladding depending on the applications ~~in question~~**sought**.

[00135]   In the embodiment of ~~figure~~**Figure** 3, the cladding 19 surrounds the core 17 solely in the zone of interaction I comprising the grating 21. In other words the core 17 carrying an input light wave E, penetrates the cladding by one of its ends with the reference 19a and leaves it after the zone of interaction I by carrying a wave S corresponding to the part of the wave E that has not been coupled to the cladding in the zone of interaction. The coupled part of the wave has the reference C. The core may be connected upstream and/or downstream of the zone of interaction to optical

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elements (not shown) which may or may not be integrated in the substrate 15.

[00136]   In this example, the input of the core 17 is optically coupled to an optical fibre 34 and at its output to an optical fibre 31 by means of ~~to des ferulae~~**ferrules,** respectively**,** with the references 35 and 30.

[00137]   To make a double detection from the sampling device ~~of~~**shown in** this figure, ~~then~~ the fibre 31 simply has to be connected to a second recovery and treatment element (not shown). Thus, the coupled wave C in the cladding is measured at the output of the cladding ~~for~~**by** the element 33 and the complementary output wave S is measured at the output of the core 17 for the second recovery and treatment element.

[00138]   In this embodiment, the recovery and treatment element 33 comprises an optical element which is ~~advantageously,~~ **for example,** a measuring element such as a photo detector **(**possibly associated to adaptive optics~~; this~~**). This** element 33 is positioned directly at the end 19b of the cladding. If the input of the measuring element is adapted to the end 19b of the cladding or vice versa, then all the coupled wave C in the cladding may be recovered ~~for~~**by** the measuring element.

[00139]   Figure 4 ~~diagrammatically~~ shows**,** in **a** cross section**,** a second example of sampling device **according to an embodiment** of the invention ~~created in integrated optics.~~**.**

[00140]   This cross section is also in a plane parallel to the surface of the substrate and ~~containing~~**contains** the direction z of propagation of the light wave.

[00141]   This figure can be distinguished from ~~figure~~**Figure** 3 by the recovery and treatment element which comprises a second zone of interaction I' capable of coupling the wave C spreading through the cladding 19, in a second core 24 and an optical element 26.

[00142]   More precisely, the zone I' is formed in the substrate 15 ~~for~~**by** a second guide core 24 ~~situated~~**located** in a portion of the cladding 19 and ~~for~~**by** a grating 23 capable of coupling in the second core all or part of the wave C spreading through the cladding. In this example, ~~this is~~the core 24 ~~which~~ leaves the cladding ~~by~~**at** the end 19b~~, which~~**.** **The core 24** is connected to the optical element 26.

[00143]   The characteristics of the second zone of interaction are most often the same as those of the zone of interaction I as its function is to couple the wave C in the second core.

[00144]   This embodiment is ~~a little~~**slightly** more complex than the previous one ~~but has the advantage of making possible~~**.** **It allows** the recovery of the coupled wave on a normal sized guide. The core 24 can ~~then~~be connected either directly or via an optical fibre to the optical element 26.

[00145]   This type of component can also be used as a multiplexer/demultiplexer in which case the core 24 is connected to an optical element depending on the application ~~in question.~~**sought.**

[00146]   As in ~~figure~~**Figure** 3, the non coupled wave transported for the core at the output of zone I can be recovered and treated.

[00147]   Figure 5 ~~diagrammatically~~shows a cross section in a plane parallel to the surface of the substrate and containing the direction z of propagation of the light wave, a variant of ~~figure~~**Figure** 3. In this example, only the wave C is recovered.

[00148]   This cross section ~~is~~**can be** distinguished from that of ~~figure~~**Figure** 3, in that the core 17 does not leave the zone of interaction I. The non coupled wave S in the cladding is dispersed inside ~~it~~**the cladding** without being recovered, ~~whilst~~**while** the wave C is coupled and guided in the cladding

and is recovered ~~for~~**by** the recovery and treatment element 40 connected to the end 19b of the cladding.

[00149]   The optical element 33 (of ~~figure~~**Figure** 3), 26 (of ~~figure~~**Figure** 4) or 40 (of ~~figure~~**Figure** 5) is ~~advantageously~~ a photo detector or a group of photo detectors, capable of characterising at least spectrally the measured wave possibly associated to a formatting element such as a lens, a lens fibre to target the wave to be measured on the photo detector.

[00150]   The characteristics of the zone(s) of interaction are determined depending on the one or more spectral bands of the initial wave E that are to be filtered.

[00151]   Figure 6 diagrammatically shows in **a** cross section in a plane parallel to the surface of the substrate and containing the direction z of propagation of the light wave, a variant of ~~figure~~**Figure** 4. This figure ~~is~~**can be** distinguished from ~~the figure~~**Figure** 4 by the cladding 29 which creates ~~the~~ two zones of interaction I and I'~~, the~~. **The** other elements are the same as those of ~~figure~~**Figure** 4 and have the same references.

[00152]   The cladding 29 has a variation of section between the two zones of interaction I and I' in order to modify the distribution of the guided modes in the cladding. Thus, each of these zones of interaction I and I' is ~~characterised for~~**characterized by** a spectral transfer function~~,~~ respectively~~,~~ T1 and T2 defined for the grating selected 21, 23, the size of the core 17, 24 and the size of the cladding. In ~~the~~**this** case ~~of this example~~, the two cores 17 and 24 have the same size. The change in the size of the cladding then permits not only the position of the filtering bands to be changed ~~absolutely~~**separately** (with respect to a fixed reference) but also relatively (of the maximums between the transfer functions).

[00153]   Thus, if the pitch of the two gratings 21, 23 is adjusted so that the maximums are at the same spectral

position for the two gratings, ~~then at the central wave length corresponding to this maximum,~~ the first grating 21 will couple the fundamental mode of the core 21 to a cladding mode~~,~~ ~~this~~ **at the central wave length corresponding to this maximum.** **This** mode will then be guided in the cladding 19 up to the other grating 23. The inverse coupling will then take place and the signal filtered for the grating 21 will be situated in the core 24. For the other coupled spectral bands, the cladding 19 will also guide the coupled modes to the second grating ~~23 but~~**23. However,** the change of size of cladding means that the core 24 can no longer be coupled with the second grating. At the core output 24, only one of the coupled modes in the cladding can be recovered.

[00154] To modify the distribution of the guided modes in the cladding, it is also possible to decentre the core 17 with respect to the other core 24. Such a decentration permits, as previously ~~seen~~**discussed**, to add a filtering element between the two zones of interaction placed in series for a common cladding.

[00155] It is ~~of course~~**also** possible to combine the decentration of the two cores and the variation of the cladding section.

[00156] Figures 7a and 7b show diagrammatically the device of the invention respectively in a cross section in a plane (xz) parallel to the surface of the substrate and containing the direction z of propagation of the light wave (~~figure~~**Figure** 7a) and in a plane (yx) perpendicular to the surface of the substrate and perpendicular to the direction z of propagation of the light wave (~~figure~~**Figure** 7b).

[00157] These figures offer another solution for performing double detection. Figure 7a ~~is~~ shows ~~in~~ the substrate 15 **having** a zone of interaction I formed ~~for~~**by** the cladding 19, the guide core 17 and the grating 21. In this example, the core penetrates the cladding by the end 19a and

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~~transverses it to its~~**traverse the cladding to** output end 19b without being separated from the cladding.

[00158]   A recovery and treatment element 50 is ~~then~~ connected conjointly to the output ends of the core and the cladding. This element is, for example, a CCD matrix type detection unit (~~which is to say~~**or** a matrix detector unit) possibly associated to adaptation optics. In ~~figures~~**Figures** 7a and 7b, the element 50 is a strip of detectors 51.

[00159]   Figure 7b is a cross section in the plane of these detectors.

[00160]   Thus, ~~as previously seen~~ part of the input light wave E is coupled (wave C) in the zone of interaction I ~~whilst~~**while** the non coupled part (wave S) continues to be transported by the core 17. The concentric circles, respectively with the references C and S, diagrammatically show these waves.

[00161]   The wave S is recovered ~~for~~**by** one or more detectors located in the centre of the matrix ~~whilst~~**while** the wave C is recovered ~~for~~**by** the other detectors.

[00162]   ~~In fact~~**Indeed**, if the section of the cladding is large enough, the cladding mode(s) have their energies mainly distributed outside of the central zone. The distribution of the energies of the waves C and S is shown diagrammatically by way of example above the strip of detectors ~~figure~~**Figure** 7b. Consequently, the central detection elements ~~provide the measurement of the~~**are configured to measure** signal S and the other elements of the matrix ~~provide the measurement of the~~**are configured to measure** complementary signal C.

[00163]   ~~The~~**Furthermore, the** independence of the core and the cladding ~~furthermore permit~~**permits** the size of the cladding to be adapted to a given matrix of detectors. ~~Even though~~ **While** the cladding of an optical fibre is circular and poorly adapted to the line form of the detectors.

[00164]   The sampling device **according to an embodiment** of the invention may be used with many optical components. It is particularly useful with filtering components such as linear filters or gain flatteners used, for example, with optical amplifiers to permit the amplifier to be controlled.

[00165]   Figure 8 shows precisely by way of example the use of a sampling device **according to an embodiment** of the invention with an optical amplifier.

[00166]   This figure is in a plane yz containing the sampling device of the invention which in this example is of the same type as that of ~~figure~~**Figure** 3. The optical amplifier associated to this sampling device is integrated in the same substrate 15 as the latter. It comprises an amplification element shown schematically by a shaded zone 45 which may be a spiral guide core whose input is connected to a coupler 47 and whose output is connected to the core 17 of the sampling device.

[00167]   The coupler 47 comprises a first input connected to a guide core 49 from which the light wave E is introduced to be amplified and a second input connected to a guide core 51 from which a pump wave P capable of pumping the active zone 45 is introduced. The coupler 47 permits the amplifying element which is connected to the coupler output to be supplied with the waves to be amplified and pump. At the amplifier output, the core 17 thus transports the amplified wave E.

[00168]   ~~In general, due~~**Due** to the non homogeneity of the gain of the active 45 on the amplification spectral band, the amplified wave undergoes deformation. A gain flattener filter ~~is therefore advantageously~~**may be** connected to the amplifying element 45 output. ~~Thus filter is, in~~ **In an embodiment of** the invention, **the filter is** created ~~for~~**by** one or more artificial cladding gratings to ~~coupler~~**couple** in a cladding 19 the amplification excess of the wave E. The sampling device is

then used as a filter as it permits the wave non transmitted
for**by** the core 17 to be recovered at the output of the
cladding 19. A recovery and treatment element of the wave C
is therefore optically connected to the end 19b of the
cladding whilst**while** the output wave S is available at the
output of the core 17.

[00169]   As the non transmitted light energy C of the wave
is proportional to the energy S transmitted, by the core 17,
the measurement of the energy guided in the cladding mode(s)
permits the output power level of the amplifier to be
controlled.

[00170]   This control is especially important**may be useful**
when a constant level of amplification must be ensured in time
is desired.

[00171]   The use of the non transmitted signal by the core
17 and consequently**may be** lost, to**. The** control **of** the output
power level of the amplifier has the double advantage of**does**
not requiring**require** any additional coupler type components to
carry out the sampling and **does** not introducing**introduce** any
output losses. In figure**Figure** 8, the sampling device and the
amplifying element are made in the same substrate**. However**,
but of course these two elements may be made in two substrates
that are different or the same, the**. The** amplifying element
can be an amplifying fibre connected to the sampling device
made in a substrate.

[00172]   Figure 9 shows diagrammatically in a cross
section, another application of the sampling device pour the
spectral control of a linear filter.

[00173]   In this figure, a source 60 with a wide spectrum
61 (shown close to the source) is optically connected to a
guide core 62 made in a substrate 15. The core 62 guides the
signal from the source to an optical fibre 63 comprising a
Bragg grating 64. The latter**Bragg grating 64** reflects a fine
spectral band 65 (shown close to the grating 64) in the fibre

63. The spectral band signal 65 then returns into the substrate 15 by a guide core 66 made in the said substrate. The core 66 transports this signal to a sampling device 67 of the invention.

[00174]   In this example, the device 67 is of the same type as that shown in ~~figures~~**Figures** 7a and 7b. The strip of photo detectors 50, for example a CCD strip, is connected to the ends of the cladding and the core of the sampling device and measures the filtered signals I_1 and non filtered signals I_2 of the zone of interaction. A central analysis unit 69 is for example connected to the strip 50 to treat the signals measured.

[00175]   When the Bragg grating **64** is subjected to parameter variations (temperature, constraints, etc.) the reflected ~~wave length~~**wavelength** varies. The signal measured at the output of the sampling device ~~of the invention~~ thus permits the value of this variation to be determined.

[00176]   The sampling device **according to an embodiment** of the invention permits functions ~~that are more or less evolved~~ to be created by modifying the various elements of the artificial cladding grating. The ~~latter~~**artificial cladding grating** permits a linear signal to be transmitted depending on the ~~wave length~~**wavelength** at a given range. Thus, if λ_m is the central ~~wave length~~**wavelength** of the filter, the transmission is given for a relationship of the following type close to this ~~wave length~~**wavelength**:

$$T(\lambda) = a \times (\lambda - \lambda_m) + t_m \qquad (3)$$

[00177]   If ~~we measure simultaneously~~ the signal transmitted I_2 and its complementary signal I_1 **are measured simultaneously** in decibels (for example**, by using** a CCD strip) and that the two are separated, we ~~obtain~~**the following relation is obtained**:

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$$I_2^{dB} - I_1^{dB} = 10 \log(1 - t_m - a \times d\lambda - 10 \log(t_m + a \times d\lambda) \qquad (4)$$

[00178]   Thus, contrary to the prior art, the double detection is carried out in the same device, which ~~permits~~**allows** the measurement to be made insensitive to intermediate losses and insensitive to fluctuations of intensity of the measurement.

[00179]   Furthermore, the use of an artificial cladding grating ~~of the invention has the double advantage of both performing~~**allows to perform both** the filtering function as well as ~~that of~~ sampling~~, which is~~. **This results in** a gain in cost and space.

[00180]   To resolve any possible problems of non linearity of the measurement depending on the spectral offset, the spectrum of the component may be adapted. Thus, if desired:

$$I_2/I_1 = \alpha \times d\lambda + \beta_m \qquad (5)$$

[00181]   The response of the sampling device simply needs to be adjusted ~~of~~ so as to have a defined transmission on the useful spectral band ~~from~~**with** the equation:

$$T(\lambda) = \frac{1}{1 + \alpha \times (\lambda - \lambda_m) + \beta_m} \qquad (6)$$

[00182]   This system may be applied ~~in particular~~ to the frequency control of a fine source or the offset measurement of Bragg grating sensors.

[00183]   ~~Hereunder~~**In the following paragraphs, an embodiment** is described in conjunction with ~~the figures~~**Figures** 10a to 10d ~~an embodiment~~, using the ion exchange technology,

of a zone of interaction I used in a sampling device **according to an embodiment** of the invention.

[00184]   These figures are cross sections of the zone I in a plane xy.

[00185]   Thus, ~~figure~~**Figure** 10a shows the substrate 15 containing beforehand B ions. A first mask 71 is created for example by photolithography one of the faces of the substrate~~,~~ ~~this~~. **This** mask comprises an opening determined according to the dimensions (width, length) of the cladding 19 that are to be obtained.

[00186]   A first ionic exchange is ~~then~~ carried out between the A ions and B ions contained in the substrate, in a zone of the substrate situated close to the opening of the mask 71. This exchange is obtained for example by soaking the substrate ~~equipped~~**along** with the mask in a bath containing A ions and by ~~possibly~~**optionally** applying an electrical field between the face of the substrate on which the mask is positioned and the opposite face. The zone of the substrate in which this ionic exchange ~~has been made~~**takes place** forms the cladding 19.

[00187]   To bury this cladding, a step of re-diffusing the A ions is carried out with or without the help of an electrical field applied as previously described. Figure 10b shows the cladding after a step where it is partially buried. The mask 71 is generally removed prior to this step.

[00188]   The creation of the cladding of the invention is therefore similar to the creation of a guide core but with different dimensions.

[00189]   The following step represented in ~~figure~~**Figure** 10c ~~consists of~~**comprises** forming a new mask 75 on the substrate for example by photolithography possibly after cleaning the face of the substrate on which it is made. This mask comprises patterns capable of permitting a guide core 17 to be made ~~and in particular when~~. **When** the core comprises a

grating, the mask patterns 75 may be adapted to the grating patterns to be formed.

[00190]   A second ionic exchange is then carried out between the B ions of the substrate and the C ions which may or may not be the same as the A ions. This ionic exchange may be carried out as previously described by soaking the substrate in a bath containing C ions and by ~~possibly~~**optionally** applying an electrical field.

[00191]   Finally, ~~figure~~**Figure** 10d shows the component obtained after burying of the core 17, obtained by re-diffusion of the C ions and final burying of the cladding, with or without the use of an electrical field. The mask 75 is generally removed prior to this burying step.

[00192]   The conditions of the first and second ionic exchanges are defined so as to obtain the desired differences in the refractive indices between the substrate, the cladding and the core. The adjustment parameters of these differences are in particular the exchange time, the temperature of the bath, the concentration in ions of the bath and the presence or absence of an electrical field.

[00193]   In one ~~example of an~~ embodiment, the substrate 15 is ~~mad eof~~**made of** glass containing Na^+ ions, the mask 71 is made of aluminium~~ and if~~**. If** the cladding is uniform~~ it~~**, the mask 71** has an opening of ~~around~~**about** 30 µm in width (the length of the opening depends on the desired length of cladding for the **desired** application~~ in question)~~.

[00194]   The first ionic exchange is performed with a bath comprising Ag^+ ions at a concentration of approximately 20%, at a temperature of around 330°C and during an exchange time of ~~around~~**about** 5 minutes. Re-diffusion of the ions first takes place in open air at a temperature of ~~around~~**about** 330°C for 30 s, then the cladding is partially buried in the glass. This burying is carried out for a re-diffusion in a sodium bath at a temperature of ~~around~~**about** 260°C for 3 minutes.

[00195]   The mask 75 is also made of aluminium and has an opening pattern of ~~around~~**about** 3 µm in width (the length of the pattern depends on the desired core length for the **desired** application~~in question~~).

[00196]   The second ionic exchange is performed with a bath also comprising Ag⁺ ions at a concentration of ~~around~~**about** 20%, at a temperature of ~~around~~**about** 330°C and for an exchange time of ~~around~~**about** 5 minutes, with a re-diffusion of the ions first taking place in open air at a temperature of ~~around~~**about** 330°C and for 30 s. Then the core thus formed in the glass is partially buried by re-diffusion in a sodium bath at a temperature of ~~around~~**about** 260°C for 3 minutes.

[00197]   The cladding and the core are finally buried under an electrical field, with the two opposite faces of the substrate in contact with two baths (in this example of sodium) capable of allowing a difference in potential to be applied between these two baths.

[00198]   ~~Many~~**It must be appreciated that many** variants of the previously described process may ~~course~~ be made.

[00199]   ~~As we have already seen, to~~**To** bury the cladding and the core, a variant of the process consists of depositing on the substrate 15, a layer of material 78, shown in dotted lines in ~~figure~~**Figure** 10d. To ~~make~~**allow** optical guiding ~~possible~~, this material ~~must advantageously have~~**has** a refractive index lower than that of the cladding.

[00200]   The fabrication of the component of the invention is not limited to the ion exchange technique. The component of the invention may ~~of course~~ be made by all techniques which permit the refractive index of the substrate to be modified.

[00201]   Furthermore, as ~~we have already seen~~**discussed previously**, the period, the size, the position of the grating created, with respect to the core and the cladding, are parameters which can be adapted to suit ~~the~~**specific** applications.

[00202]   The pattern of the grating can be defined on the mask permitting the cladding to be created and/or on the mask permitting the core to be created or solely on the mask permitting both the cladding and the core to be created or ~~even~~ on a specific mask solely for the creation of the grating.

[00203]   Figures 11a to 11d show examples of embodiments of masks M1, M2, M3, M4 permitting an elementary grating to be created. These figures are elevation views of masks and only show the part of the masks permitting the grating to be created. The white zones of the pattern of the masks are the openings of the masks.

[00204]   These masks permit a periodic grating of period Λ to be obtained. The mask M4 permits a grating to be obtained for segmentation ~~whilst~~**while** the masks M1 and M2 permit a grating to be obtained for variation of the width of the patterns. Furthermore, the mask M3 permits a grating to be obtained for the introduction of a periodic disruption P in the substrate for example next to the core 70.

[00205]   The previous figures show examples of gratings formed in the guide core.

[00206]   Figure 12 shows an ~~embodiment of an~~ elementary grating 80 created for segmentation in a zone of interaction, both in the core 17 and in the cladding ~~19.~~**19, according to an embodiment of the present invention.**

[00207]   Thus, in ~~figure~~**Figure** 12, the grating 80 is formed in the cladding 19 by ~~alternation of~~**alternating the** period Λ of zones 82 of variable lengths ~~considered~~ **(**in the direction z of propagation of a light wave**)**. As the core is ~~furthermore~~ included in the cladding, at least in the zone of interaction, the grating is also included in the core~~, in.~~ **In** other words the core also comprises refractive index zones that are different from that of the rest of the core.

[00208]   The gratings may be formed by all of the ~~traditional~~**conventional** techniques permitting the effective index of the substrate to be modified locally in the core and/or in the cladding.

[00209]   ~~They can therefore~~**The gratings may** be created during ionic exchanges permitting the core and/or the cladding to be created or during a specific ionic exchange. ~~They can~~ **The gratings may** also be obtained by etching ~~of~~ the substrate ~~on~~**in** the zone of interaction or by ~~radiation.~~**irradiation.** In particular, the gratings may be obtained by exposure of the core and/or the cladding ~~with~~**to** a CO_2 type laser. By producing localised heating, the laser ~~permits~~**allows** ions to be re-diffused locally and thus ~~include~~**create** the grating pattern.

[00210]   ~~By way of~~**For** example, the substrate can be ~~swept~~**scanned** with a laser beam modulated**,** for example ~~by its~~**,** **in** amplitude so as to introduce modulation ~~of~~**in** the grating to the desired pitch.

[00211]   The pattern of the grating depends on the **targeted** applications ~~targeted~~. In particular, the grating may have a variable period (chirped grating) or variable efficiency (apodised grating).

ABSTRACT OF THE DISCLOSURE

INTEGRATED OPTICS SAMPLING DEVICE AND ITS FABRICATION METHOD

The invention relates to a sampling device comprising in a substrate (15), a wave guide core (17) capable of transporting a light wave E and an optical cladding (19), at least one portion of the cladding surrounding at least one portion of the core in a zone called the zone of interaction (I), the said zone comprising among others a grating (21) capable of coupling in the cladding, part of the light wave, the coupled part being called the coupled wave C, the refractive index of the cladding being different to the refractive index of the substrate and lower than the refractive index of the core at least in the part of the cladding next to the core in the zone of interaction. The cladding of the device is advantageously connected to a recovery and treatment element (33) for all or part of the coupled wave (C).

A sampling device includes a substrate and a wave guide core in the substrate. The wave guide core is configured to transport a light wave. The sampling device further includes an optical cladding in the substrate. At least a portion of the cladding surrounds at lead a portion of the core in a zone of interaction. The zone includes a grating configured to couple, in the cladding, a part of the light wave to form a coupled wave. A refractive index of the cladding is different from a refractive index of the substrate and the refractive index of the cladding is lower than a refractive index of the core at least in a part of the cladding adjacent to the core in the zone of interaction.